OBPR Direction and Research Plan

Howard D. Ross
Office of Biological and Physical Research
NASA Headquarters
Washington DC 20545
hross@hq.nasa.gov

This Research Plan presents the mission, acknowledges the past accomplishments, and clarifies the priorities and intended direction for scientific investigations, strategic research, and commercial and technological developments to be sponsored by NASA's Office of Biological and Physical Research. The audience for this Plan is intended to be the relevant research communities, agency and federal management, and Congressional interests. It was prepared in response to Congressional direction (e.g. HR.106-988, S.107-222) for a ten-year research plan that includes operational requirements for the research to be done on the International Space Station (ISS).

For nearly 40 years, NASA has sent people on short forays in orbit to conduct brief scientific and engineering experiments in apparent weightlessness, i.e. in microgravity. We sought to understand the role of gravity in the physical universe and on life itself. We learned that the effects of gravity that we experience on Earth limit our knowledge of many aspects of biology, physics and chemistry. We also learned that biological systems – from cells to plants to people -- undergo changes from long-term space habitation that are not completely understood. Thus, humankind's eventual travel beyond earth's orbit into new environments poses profound challenges. We must discover ways for space explorers to withstand hazards for which humanity's experience on Earth never prepared them. As we discover, we also will seek new knowledge, technology, and commerce to realize benefits for people on earth, and innovations that enable scientific exploration safely, productively, and affordably.

The OBPR and its predecessor organization have had a successful history of spaceflight research in life and microgravity sciences. Flagship missions flew successfully on the Shuttle and the Mir, in anticipation of the creation of the International Space Station. These programs, which evolved into the OBPR research portfolio of today, nearly doubled in the last 6 years—from fewer than 350 to greater than 1,000 research investigations. The published journal articles and patented technologies reflect this growth. In 2001, our 852 principal investigators produced 3,499 research publications. Similarly, the commercial programs grew over the same time period -- from nascent entities to a set of commercial space centers that today are working with 150 US companies and 80 product lines in multiple disciplines.

For the first time, the laboratory of the International Space Station (ISS) offers scientists and engineers a permanent microgravity facility with much more power, crew time, and physical volume than the Space Shuttle, the Mir, or any other laboratory. As stated by the NASA Administrator, *"The International Space Station (ISS) is without precedent in the history of the U.S. space program… In the unique environment of space combined*

with research, exploration, human innovation and creativity, the ISS holds the potential to forever improve the quality of life on Earth."

The Office of Biological and Physical Research endeavors to lead our research to realize this potential – not only in the ISS, but in all of our experiments in space. The environment on the ISS and other space-based laboratories makes the research supported in this Office unique to the NASA mission, and separates it from the research by other agencies.

The OBPR Mission

NASA has a new Vision: *To improve life here, to extend life to there, to find life beyond*. Our contribution to the Agency to realize this Vision is written as a Mission Statement that motivates our research on the ISS and is the framework for the activities of OBPR:

Humans will extend the exploration of space. To prepare for and hasten the journey, OBPR must answer these questions through its research:

- **How can we assure survival of humans traveling far from earth?**
- **What must we know about how space changes life forms, so that humankind will flourish?**
- **What new opportunities can our research bring to enrich lives and expand understanding of the laws of nature?**
- **What technology must we create to enable the next explorers to go beyond where we have been?**
- **How can we educate and inspire the next generations to take the journey?**

This Research Plan provides a top-level description of the OBPR direction to answer these questions and fulfill our mission. The answers will not come easily. A systematic approach, utilizing a combination of national, international and commercial resources (both on earth and in space) and a clear stable investment strategy are required. These questions engender more detailed questions and still more detailed research plans and roadmaps. For example, the above questions are further delineated in the following table:

ORGANIZING QUESTION	DETAILED QUESTIONS / TOPICS
How can we assure the survival of humans traveling far from earth?	What knowledge and tools are needed to enable the practice of medicine in space?
	How does the human body and its physiology adapt to space flight, when is it appropriate to counteract those adaptive effects, and by what means can we do so?
	What is needed to protect human space explorers from the cosmic radiation that bombards their spacecraft and their bodies?
	How can we provide an optimal environment to support behavioral health and human performance in space flight?
What must we know about how space changes life forms, so that humankind will flourish?	Does space affect life at its most fundamental levels, from the gene to the cell?
	How does long-term exposure to space affect organisms?
	How does space affect the development and lifecycles of organisms?
	How do systems of organisms and their interactions change in space?
What new opportunities can our research bring to enrich lives and expand understanding of the laws of nature?	The six NRC-defined "grand challenges" in physics, areas of highest priority for scientific advancement and potential technological development, are: * Developing quantum technology * Understanding complex systems * Applying physics to biology * Creating new materials * Exploring the universe * Unifying the forces of nature
	Market-driven commercial research that supports national goals, such as contributing to economic growth of the nation through increased GNP and sustaining human capital in the areas of science and technology
What technology must we create to enable the next explorers to go beyond where we have been?	How can we change spacecraft systems to lessen the required up-mass, volume, power, and crew time?
	How can technology help human productivity and well being during extended isolation from Earth?
	How can we ensure that the crew is living in a safe and comfortable environment?
	What is the optimal way to support environmental health for crewmembers of space flights?
How can we educate and inspire the next generations to take the journey?	Educational Outreach
	Public Outreach

While the past demonstrated the merits of our research and validated the concept of an orbital laboratory, new areas of emphasis will carry OBPR beyond microgravity-based, curiosity-driven studies into a strategic research thrust that includes topics such as radiation health and protection, bioastronautics, and technology aimed at sustained human exploration of space. For humans to venture into and to explore space beyond where they have been, NASA must be able to provide the same kind of safe environmental cocoon for space explorers that Earth provides for us. The challenge begins with safe and renewable air to breathe, water to drink, and food to eat. A sufficient depth of understanding of how humans and other life forms adapt to the effects of space flight is essential to provide appropriate medical support tools to maintain

human health. To enable this, and to ensure that we understand physical and biological processes in space well enough to exploit them safely, OBPR must provide an integrated research product that answers the key questions in our mission. The OBPR's sponsorship of research, therefore, is evolving to focus on answering these questions. Research roadmaps – both general and specific – will form the basis of time-phased competitive solicitations for research and technology and our research activities on the ISS.

The human exploration of space is one of the great voyages of discovery in human history. This is why it is both so compelling and so challenging. It must be anticipated that explorers will encounter many unforeseen difficulties as well as many opportunities that are beyond our current vision. We must make sure that they have the tools and knowledge available to respond to the challenges they encounter in creating habitats and using the resources available to them in new environments. The biomedical, biological, scientific and engineering research communities bring critical talents to this effort, and represent a segment in the national fabric of science, engineering, and education that must be enlisted in order to assure the long-term success of the Enterprise. This community has a long history of participation in other mission-driven research efforts. In collaboration with NASA's own researchers, this community will continue to be the centerpiece upon whom we rely to develop research and technology that has high scientific merit, significant terrestrial benefit and/or direct relevance to NASA's mission needs.